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ABSTRACT

The implications of content organization and cognitive style in relation to the design of hypertext were studied with a focus on the effects of linking structure and field dependence and independence on performance and attitudes. Subjects were 139 undergraduates classified as field-dependent or field-independent on the basis of Group Embedded Figures Test scores. The following treatment conditions were used: (1) hypertext with linear linking structures; (2) hypertext with hierarchical linking structures; (3) hypertext with hierarchical-associative linking structures; (4) hypertext with associative linking structures; and (5) hypertext with random linking structures. Results do not support the hypotheses of interaction between linking-structure types and cognitive styles for either performance or attitude, or the main effect of linking structure on performance. Field-independent subjects outperformed field-dependent subjects overall, and they tended to have better attitudes toward the approach. It is possible that lack of support for the hypothesized relations may result from methodological rather than conceptual causes, as further study could elucidate. Five figures illustrate linking structures. (Contains 28 references.) (SLD)

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Title:

Effects of Linking Structure and Cognitive Style on Students' Performance and Attitude in a Computer-Based Hypertext Environment

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Introduction

Hypertext is a way of organizing information using nonlinear text. Hypertext provides different ways from traditional text to access and manipulate information. The nonlinear characteristics of hypertext seem to change the ways people interact with information and knowledge. This may cause learning problems. However, little empirical research has examined the results of hypertext and human interaction.

One question that researchers are currently exploring is "How can we structure hypertext for maximum learning?" Based on theories of cognitive style and research in aptitude-treatment interaction, Witkin et al. (1977) suggested that educators might be able to adapt instructional treatment to the learning needs of field-dependent and field-independent learners. Therefore, there is reason to examine whether different linking structures within hypertext environments will have differential effects on learners with different cognitive styles. Such examination may indicate that it may be necessary to provide access constraints to serve as learning guidance in order to make hypertext effective for learners with different cognitive styles.

The purpose of this study was to determine the implications of content organization and cognitive style with regard to the design of hypertext. Specifically, the study examined the effects of linking structure and field-dependency and -independence on performance, as well as attitudes.

Linking Structures in Hypertext Environment

The five linking structures used in this study are based on Jonassen's (1986) three levels of hypertext structure (node-link hypertext, structured hypertext., hierarchical hypertext) and include linear linking structures, hierarchical linking structures, hierarchical-associative linking structures, associative linking structures, and random linking structures. Hierarchical linking and associative linking are most frequently advocated in the literature (Gaines, B. R. & Vickers, J. N., 1988; Smith, Weiss & Ferguson, 1988).

The five levels of hypertext structure used in this study will be: Linear (in which the nodes are linked linearly); Hierarchical (in which the linking emphasizes the relationship of type and part and the representation of hierarchies); Hierarchical-Associative (in which each node set is structured hierarchically and in which random access and direct access to any node set is provided); Associative (in which the linking provides random access and direct access to any node in the hypertext); and Random (in which any node can be linked to any other node directly). Study of different linking structures could be of benefit to instructional designers who develop materials for a variety of learners with different cognitive styles, e.g., field-dependence and field-independence.

Individual Differences and Field Dependence and Independence

According to Goodenough (1976), field-independent (FI) individuals adopt an active approach toward learning while field-dependent (FD) individuals adopt a passive approach toward learning. In classroom learning situations, FD learners appear to demonstrate poorer structuring abilities than FI learners (Goodenough, 1976). The FD learners display certain distinctive characteristics. For instance, FD students tend to depend on and be highly influenced by "authority figures" and are less able than FI students to generate alternative functions for elements or items used in a familiar way (Witkin 1977, 1979, 1981).

In this study, it is hypothesized that more structured hypertext instruction provides an organizational aid to learning, especially for FD learners. In contrast, when the text is less structured, organization must be provided by each learner, and would therefore be less facilitative for field-dependent learners. Furthermore, because FD individuals tend not to provide organization internally, FD subjects should have particular difficulty with less

structured sequences that contain, for example, associative and random hypertext links. Thus, it is expected that FD learners will recall fewer concepts than FI learners in learning from a hypertext-based lesson with associative and random links.

The Study

The purpose of this study was to examine the interactions and effects of hypertext linking strategies and field-dependence and field-independence (FDI) on recall performance and attitudes toward learning in a nonlinear hypertextual environment.

Research Questions

The research questions were as follows:

1. Is subjects' performance/attitudes significantly predicted by linking structure, FDI, and their interaction?
2. Is the interaction of linking structure and FDI significant?
3. Do the five linking structures/attitudes differ in subjects' average performance scores with FDI held constant?
4. Does FDI relate to subjects' performancev with linking structures held constant?

Independent Variable

The two independent variables in this study were linking structure type and cognitive style. The independent variable of linking structure type had five levels: linear linking, hierarchical linking, hierarchical-associative linking, associative linking, and random linking. The second independent variable was field-dependence/independence, as determined by results of the Group Embedded Figures Test (GEFT) (Witkin, et al., 1971).

Dependent Variable

The primary dependent variables included in this study were the learners' performance and attitudes. Performance was measured by a posttest that elicited recall of verbal information. Attitude was measured by an attitude survey. Both the performance posttest and attitude questionnaire were created by the researcher and reviewed by a content expert and two instructional design specialists.

Instructional Materials

Five treatments were administered to learners through a self-paced, computer-based lesson in a hypertext environment. The contents of instructional materials for the five treatment groups were based upon "Chinese Politics" which was developed by Kenneth C. Wedding (1991). The content was about the people, organizations, places and events involved in the Tiananmen Square Event of June 4, 1989, in Beijing. The content units for the five treatments were identical, but each employed a different linking strategy using linear linking structures, hierarchical linking structures, hierarchical-associative linking structures, associative linking structures, or random linking structures.

Hypertext with Linear Linking Structures

In linear hypertext, nodes are linked linearly, allowing the student to move to the next or to the previous node only (see Figure 1). This linear structure is similar to most traditional computer-assisted instruction, and thus serves as the control structure for this study. An example would be: a user selects one "Event" from the main menu and reads the information under the category of "Events". When the user finishes reading the "Event" or decides not to read anymore in "Events," he must go back to the main menu and select another category.

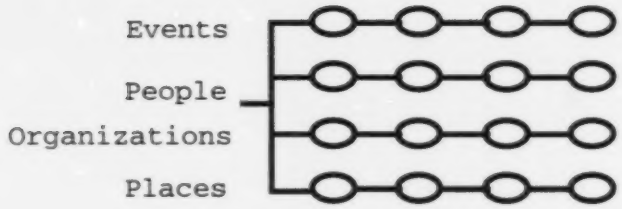

Figure 1. Hypertext with linear linking

Hypertext with Hierarchical Linking Structure

In hierarchical hypertext, a node at one level can only access nodes directly below or above it (see Figure 2). An example would be: A user moves along the hierarchical structure and reads the information in the node of "Cultural Revolution". When the user finishes reading "Cultural Revolution", he may go back to the node of the "Early History" which is the parent node of the "Cultural Revolution". Or, the user may go to "Great Leap Forward", the other child node of "Early History", which is next to the "Cultural Revolution".

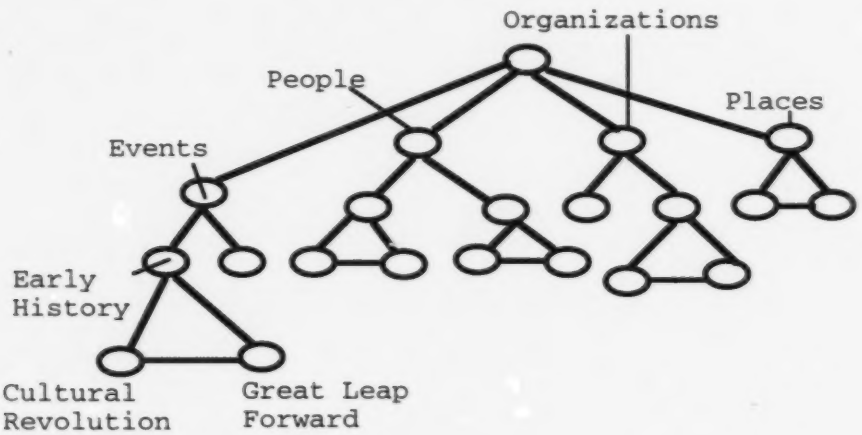

Figure 2. Hypertext with hierarchical linking

Hypertext with Hierarchical-Associative Linking Structures

In hierarchical-associative hypertext, nodes are basically linked in a hierarchical way. The associative links in this structure are provided from some nodes to other nodes that are referential to them. That is, in hierarchical-associative hypertext, a node at one level can access nodes that are directly below or above it or a node associated with it (see Figure 3). This type of linking combines associative and hierarchical linking. For example, a user moves along the hierarchical structure and reads the information in the node "Cultural Revolution." He does not know the name "Mao Zedong" which appears in this node. He may click on the name "Mao Zedong" to go to the node "Mao Zedong" to learn about him. However, when the user finishes reading "Mao Zedong", he must go back to the node "Cultural Revolution."

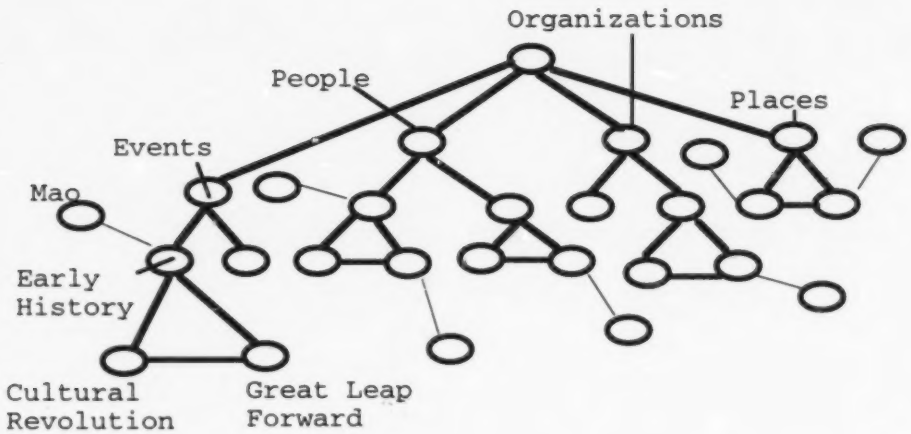

Figure 3. Hypertext with hierarchical-associative linking

Hypertext with Associative Linking Structures

Similar to hierarchical-associative linking, associative linking is based upon a global hierarchical structure. Unlike hierarchical-associative linking, which requires the user to return to the original hierarchical node from the referential node, associative linking allows the user to link to the referential node and stay in the node set to which the referential node belongs. For example, a user moves along the hierarchical structure and reads the information in the "Cultural Revolution" node. He does not know the name "Mao Zedong" which appears in this node. He may click on the name "Mao Zedong" to go to the node "Mao Zedong" to learn about him. While reading in the node "Mao Zedong," he does not understand the term "Chinese Communist Party." He may then click on the term "Chinese Communist Party" to go to the node containing information on the "Chinese Communist Party" to learn about the organization. Alternately, he could want to stay in the node set of "Mao Zedong" (People) to learn about other people in this node set. (See Figure 4.)

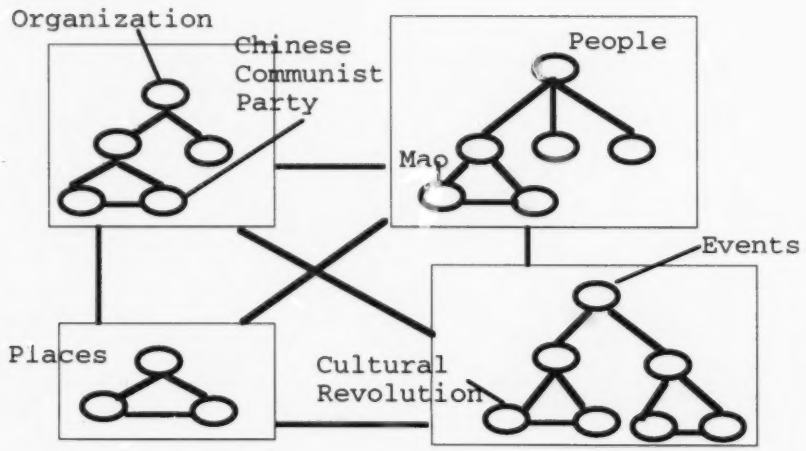

Figure 4. Hypertext with associative linking

Hypertext with Random Linking Structures

Random hypertext allows any node to be linked to any other, regardless of whether the nodes are referential to each other or not. For example, a user can jump from the node about Beijing (Places) to the node about the Chinese Communist Party (Organizations) or jump from the Cultural Revolution (Events) node to the node about Deng Xiaoping (People) directly. (See Figure 5.)

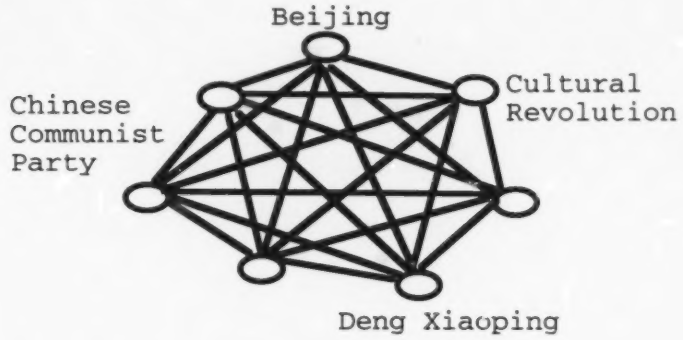

Figure 5. Hypertext with random linking

Subjects

The subjects were 139 undergraduate students enrolled in the College of Education at The University of Texas at Austin. Participation in the study was on a voluntary basis. Subjects were randomly assigned to one of the five condition groups.

Procedures

A brief introduction to the research study was presented to students. The GEFT was administered by the researcher during the class immediately after the students signed up for the experiment. Field-dependence scores were recorded. Subjects were then assigned randomly to the computer running their group treatment on it. The researcher introduced the subject of the lesson and the actual software. Subjects were informed of the grading policy and time was also provided for any questions on operating the program that the subjects had.

At the end of the instructional time, the performance posttest was administered. Upon completion of the test, an attitude questionnaire was distributed.

Data Analysis

A regression analysis test was chosen to detect the presence of any aptitude-treatment interaction. According to Pedhazur (1973), the advantage of using regression analysis is that:

> MR, Multiple Regression, is applicable to designs in which the variables are continuous, categorical, or combinations of both, thereby eschewing the inappropriate or undesirable practice of categorizing continuous variables (such as designating individuals above the mean as high and those below the mean as low) in order to fit them in what is considered, often erroneously, an ANOVA design (p.7).

In this regression analysis, a continuous value of cognitive style was to describe as many different types of subjects as there were observed. The purpose of the regression analysis is to reveal whether or not the group regressions (e.g., posttest scores on GEFT scores) are homogeneous.

Discussion of Results

This section will discuss the specific results of this study as they related to the research questions and hypotheses posed at the beginning of this research document. Since there were some significant findings as a result of data analysis, conclusions based upon the results will be suggested.

Performance

Research Question 1: Was subjects' performance significantly predicted by linking structure types, FDI, and their interaction?

Discussion. The results of this study show that 14.5% of the variance of performance can be explained by linking structure type, FDI, and their interaction. Since research on hypertext is rich in theory and poor in actual study results (Jonassen, 1986), some scholars have called for research on the structure of hypertext, proposing different types of linking structure models. Little research has investigated the effects of linking structure type and cognitive style on performance in hypertext environments. The findings of this study provide initial evidence on this issue. Linking structure types and cognitive style and their interaction have significant effects on students' performance.

Research Question 2: Was the interaction of linking structure type and FDI significant?

Discussion. Research on cognitive style suggests that consideration of style may be related to improved performance (Salmon, 1984; Keller, 1983). It was the expectation of this study that consideration of these two variables together would produce significant positive effects on performance.

It was expected that subjects with less field dependency would perform better in more structured instructional environments whereas subjects who were more field independent would perform similarly, regardless of the linking structures employed. The observations do not support these expectations. Rather, findings are more similar to those reported by Canino & Cicchelli (1988) and MacNeil (1980). These researchers found no interaction of treatments and cognitive styles upon subjects' performance.

Research Question 3: Did the five linking structures differ in average subject performance, with FDI held constant?

Discussion. Research has shown that subjects who are more field-dependent will perform better when receiving more structured instruction (Mandler, 1967; Meshorer, 1969; Clark, 1982, 1984, 1987). The results of this study, however, do not support these findings. There was no significant difference found in performance between subjects working in a more structured environment and a less structured environment.

Research Question 4: Was FDI related to subjects' performance with linking structures held constant?

Discussion. The results of this study reveal that the subjects with higher scores on the GEFT outperform those who score lower on the GEFT regardless of instructional treatment. The results prove consistent with the studies of Carrier, Davidson, Higdon, and Williams (1984), Carrier, Joseph, Krey, and LaCroix (1933), and Frank (1983). These researchers claimed that cognitive style influences performance in general.

Attitude

Research Question 1: Was subjects' performance significantly predicted by linking structure types, FDI, and their interaction?

Discussion. The significant results of the full model regression analysis show that subjects' attitudes could be predicted by linking structure type, cognitive style, and their interaction. Some researchers have called for research on the structure of hypertext and different proposed types of linking structures (Jonessen, 1986). Little research has investigated the relationship between linking structures and cognitive styles upon attitude in hypertext. The findings of this study provide initial evidence on this issue that linking structure types and cognitive style and their interaction have significant effects on students' attitude when learning in a hypertext environment.

Research Question 2: Was the interaction of linking structure and FDI significant?

Discussion. Research on cognitive style suggests that instruction designed with consideration of cognitive style may be related to improved attitude (Clark, 1982, Salomon, 1984, Keller, 1983). It was the expectation of this study that consideration of these two variables together would produce significant positive results upon attitude.

It was expected that subjects with lower field dependency would have more positive attitudes when using less structured instruction, while subjects who are more field independent would prefer more structured instruction. The results of this study support the findings from Salomon (1984), Keller (1983) and Clark (1982). Clark (1982) indicated that field independent individuals tend to be more self-motivated and have greater expectations of achievement. Although they may learn effectively from both structured and unstructured methods, they may believe that more structured methods are more efficient in facilitating learning, so they may prefer more structured instruction. However, field-dependent individuals' motives for achievement tend to be low. They may perceive more demanding methods as providing more freedom for students to control learning time and effort level. With structured methods they can invest less effort, and their failures are less visible. Therefore, they like less structured methods, which seem to make their lives easier. The results of the calculations support the expectation that field-independent individuals prefer structured instruction.

Research Question 3: Did the five linking structures differ in average attitude score with FDI held constant?

Discussion. The findings for this question indicated that subjects tended to prefer the hierarchical structures and the hierarchical-associative structures more than linear structures.

Research Question 4: Was FDI related to subjects' attitudes with linking structures held constant?

Discussion. The results indicate that students who tend toward field-independence have more positive attitudes about learning about "Chinese Politics" from the hypertext system used for this study than those who tend toward field-dependence.

Support Data

Although no formal hypotheses were formulated for the following analyses, there were areas related to the previously stated hypotheses that served to support or elaborate upon the findings associated with them.

Prior Knowledge of Hypertext Systems

When the effect of prior knowledge of hypertext systems was taken into consideration in reviewing subjects' performance and attitudes, results showed that prior knowledge had no main effect on either performance or attitudes. Regression analysis also showed that prior knowledge cannot significantly predict subjects' performance or attitudes.

Prior Knowledge of Chinese Politics

When the effect of prior knowledge of subject content was taken into consideration in reviewing subjects performance and attitude, the results showed that prior knowledge had a

main effect on both performance and attitude. The more the students knew about the subject, the better they performed on recall of the content ($p < .01$). The more the students knew about the subject, the better attitudes they had toward the instructional materials ($p < .05$).

Conclusion

To summarize, the results of this study indicate:

1. The performance of these subjects can be predicted by linking structures, cognitive style, and their interaction.
2. The performance of these subjects cannot be predicted by the interaction of linking structure types and cognitive style.
3. There is no difference in subjects' performance when learning from hypertext systems with different linking structures.
4. Field-independent subjects outperform field-dependent subjects overall.
5. The attitudes of the subjects can be predicted by linking structure types, cognitive styles, and their interaction.
6. The attitudes of the subjects can be predicted by interaction of the linking structures and cognitive styles.
7. Students like hierarchical structures and hierarchical-associative structures more than linear structures in hypertext environments.
8. Field-independent subjects tend to have better attitudes than field-dependent subjects.

To summarize, the results of this study failed to support the hypotheses for interaction between linking structure types and cognitive styles for both performance and attitude, including a main effect of linking structure upon performance. The lack of support for these hypotheses may have been due to methodological rather than conceptual causes. It is possible that specific details of this study may have contributed to the significant findings in this research.

Recommendations for Future Research on Hypertext

1. Information seeking strategies in hypertext should be investigated. In this study, five linking structures were investigated. All the subjects were taught by the researcher about how to navigate through the program. However, important questions remain. How do users learn information navigating strategies, and how do they apply them in a non-instructional situation? What can search systems do to assist in the selection and application of strategies? The use of index menus in this study is only one representation of browse strategies. Other manifestations of these strategies could be examined, such as embedded menus or navigation maps.

2. Qualitative methods can be adopted by hypertext researchers. In situations such as these where complex interactions are likely to occur, a qualitative approach with which researchers can look for patterns may be useful in building hypotheses for qualitative studies. One approach to such a study is to examine individual pathways in a hypertext lesson. By focusing on paths that are taken, a hypertext instructional system might be improved.

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